

Advanced Research WRF Developments for Hurricane Prediction

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Advanced Research WRF

ARW



AHW

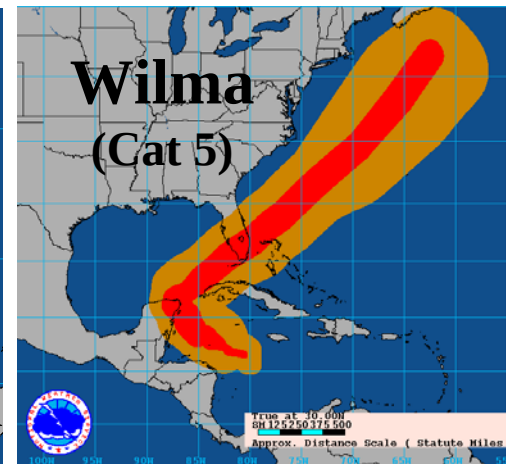
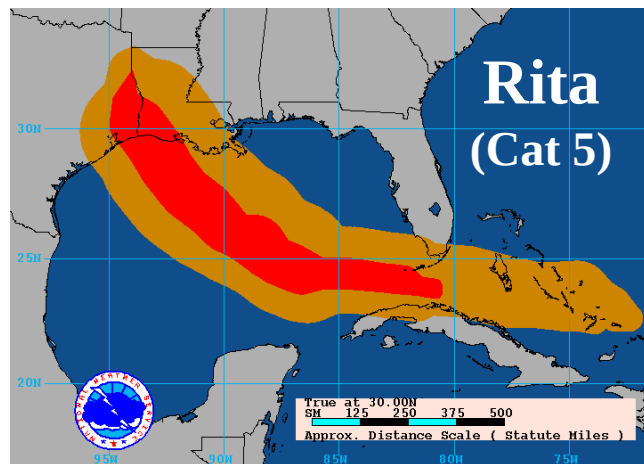
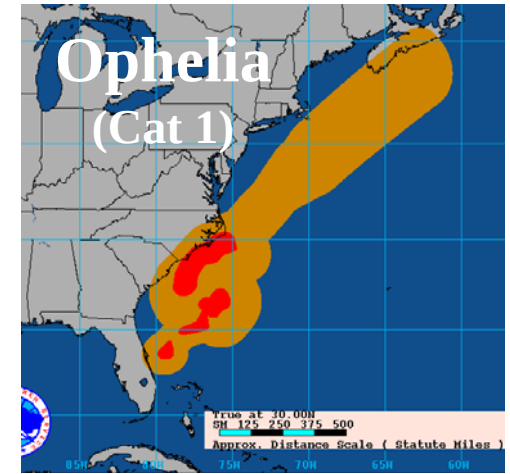
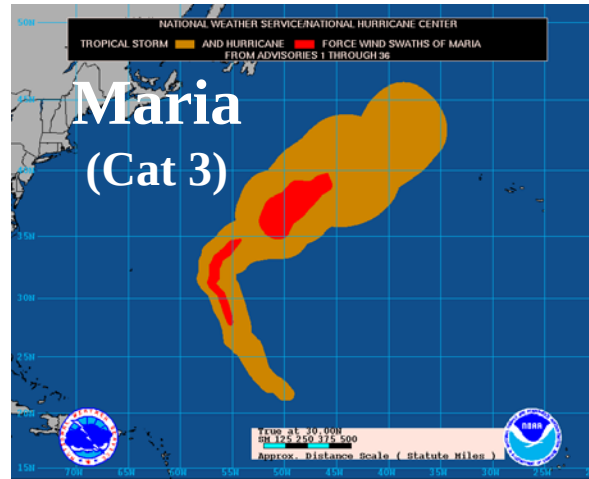
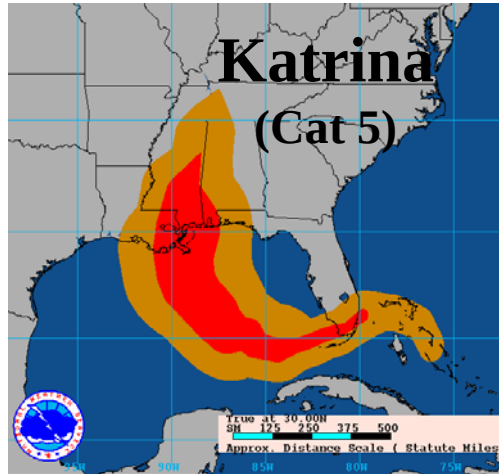
Advanced Hurricane WRF

AHW Configuration

- 2-way nested, vortex tracking grid at 4km, additional nest at 1.33 km
- No cumulus parameterization at 4 km or less.
- 12 km fixed grid nested into GFS, parameterized convection (Kain-Fritsch)
- 3-category cloud physics (no graupel), YSU PBL
- Initial conditions either GFS or GFDL

2005 Landfalling Cases Verified

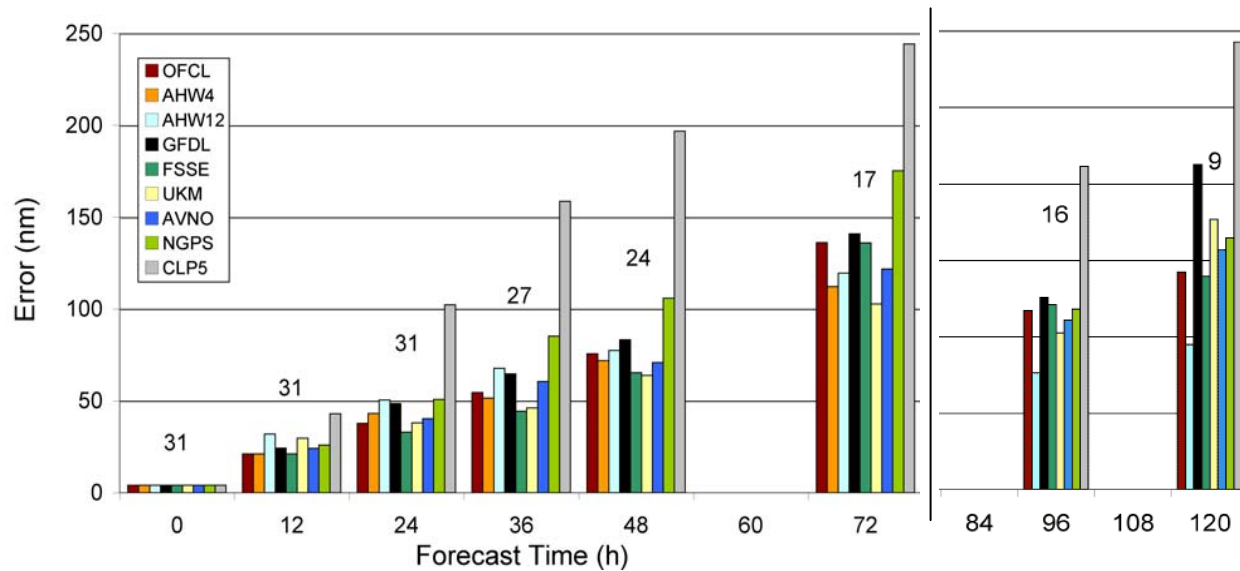
TROPICAL STORM AND HURRICANE FORCE WIND SWATHS



Results for 2005 Season

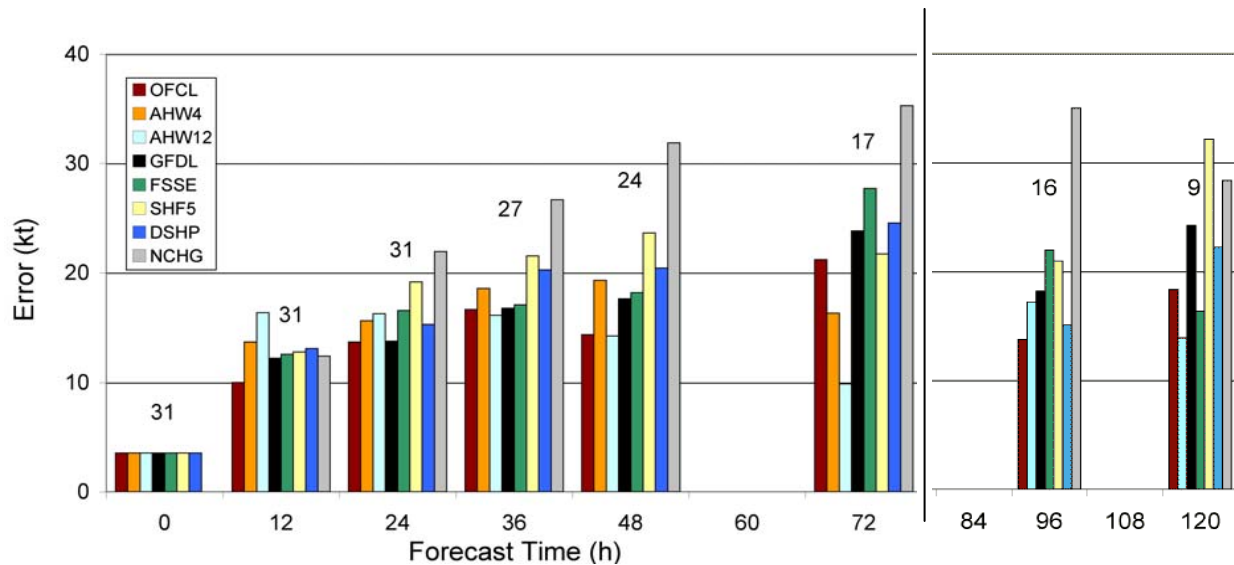
(a)

Position

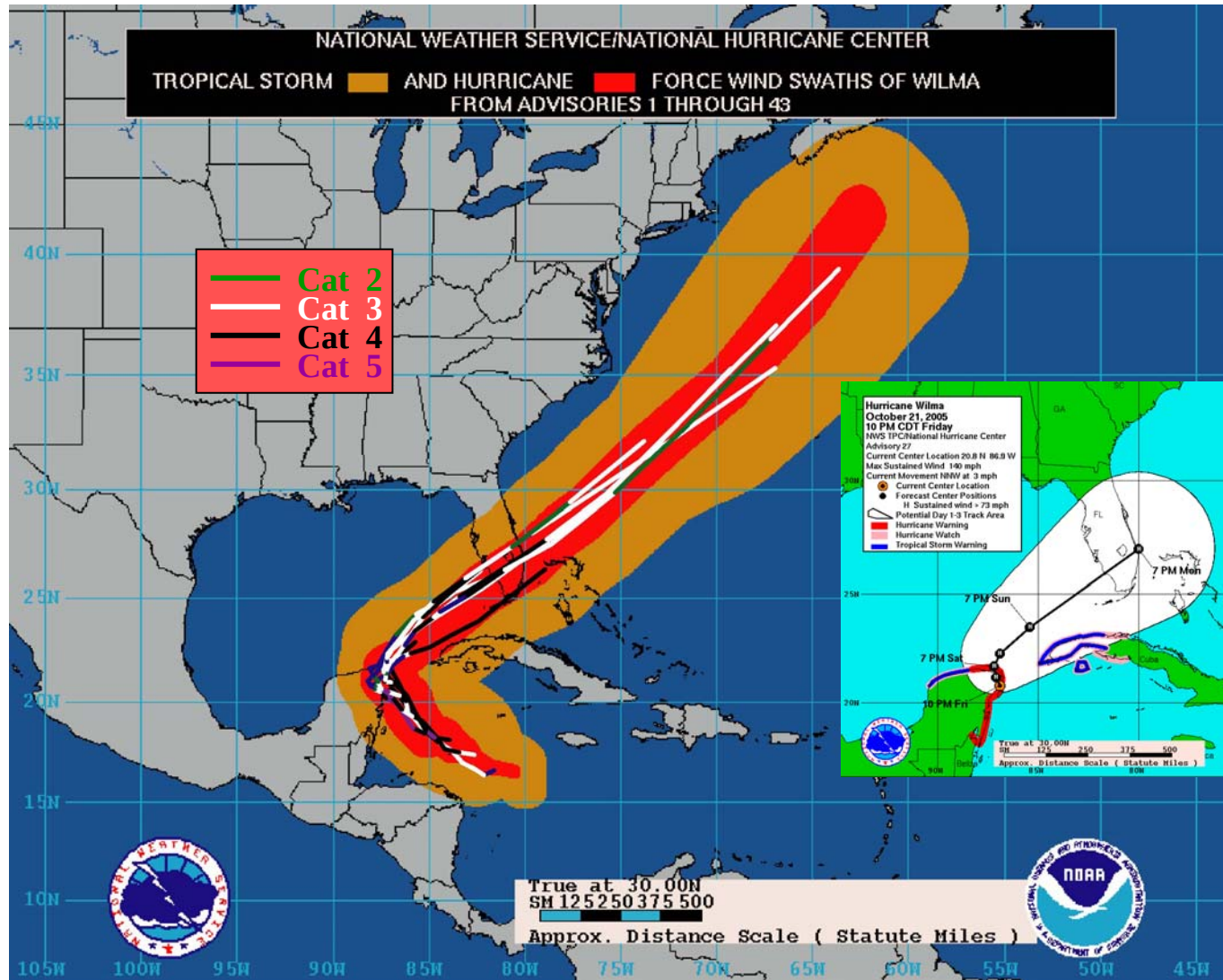


(b)

Intensity



Wilma



Key Areas Needing Improvement

- Flux Formulation
- Ocean Coupling
- Initialization
- Resolution of inner core dynamics

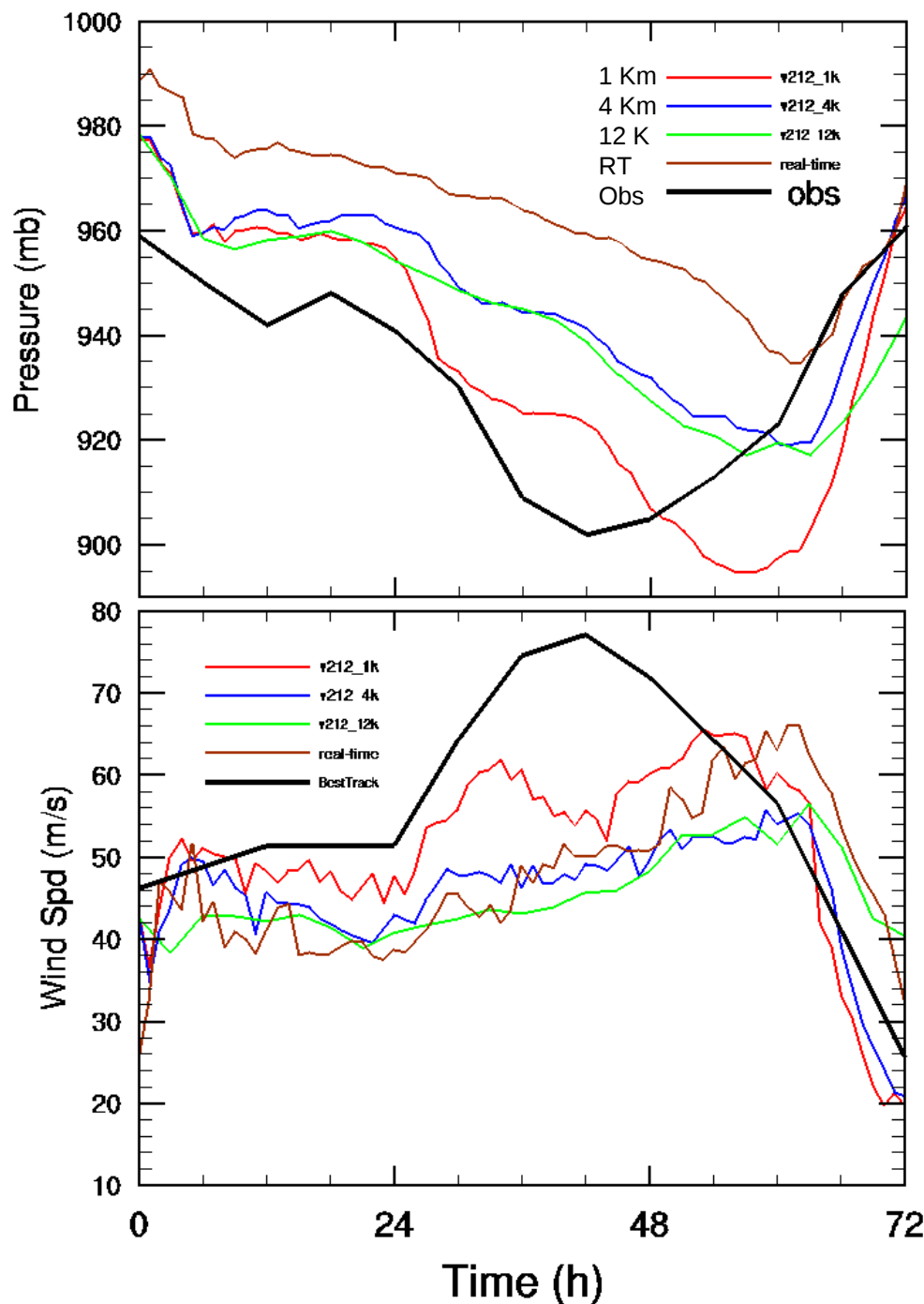
Katrina

Post real-time tests

- Flux Parameterization
 - Fix u^* over water
 - Experiment with u^* (C_D)
 - Experiment with C_K
- Couple to mixed-layer ocean model
- EnKF and 3D-VAR initialization
- Add 1.33-km storm following domain

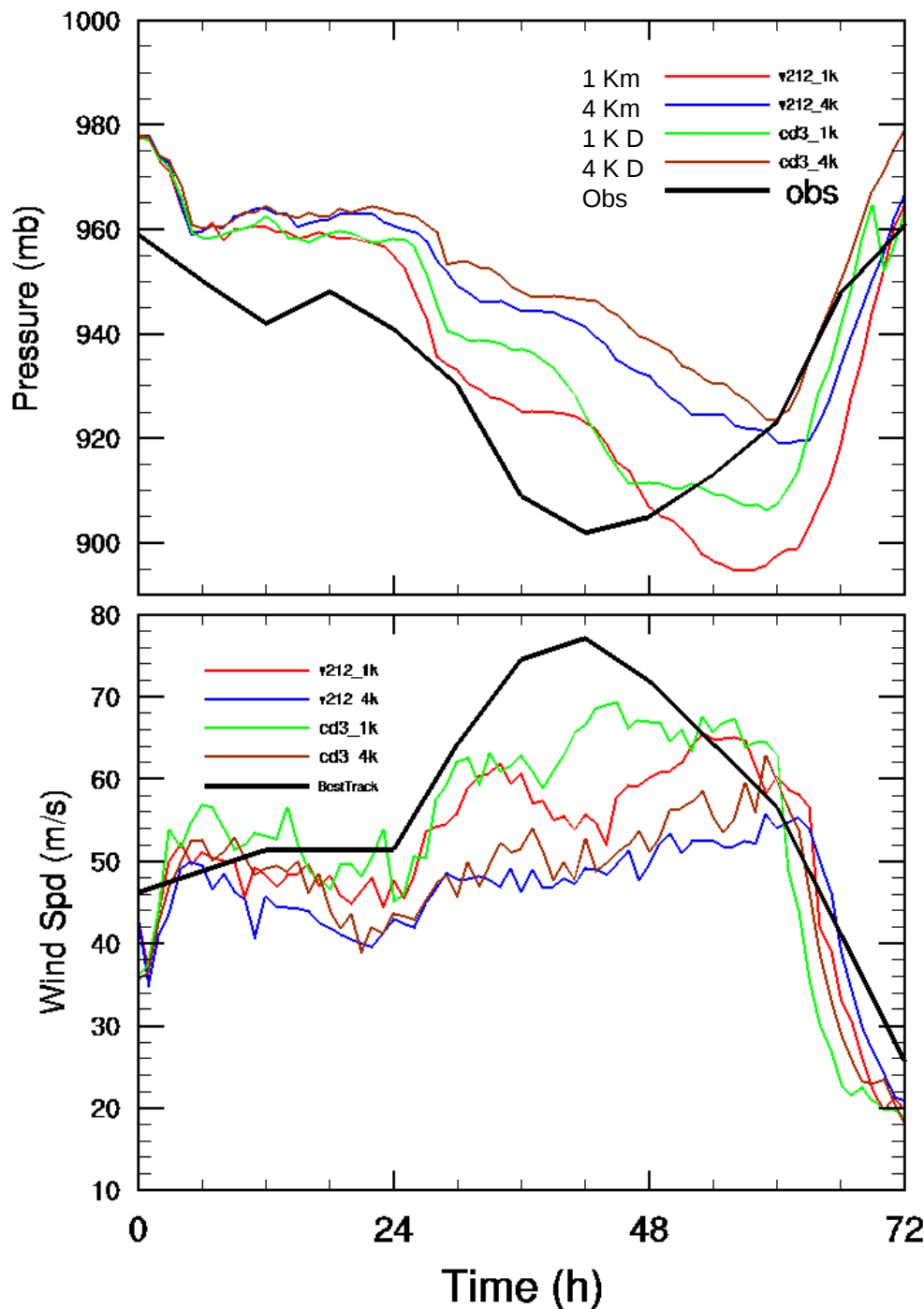
Katrina Forecasts

from 00 UTC 27
August



- 1.3 km captures part of rapid intensification
- All forecasts intensify late (erroneously)
- Obvious initialization problems (worse w/ GFS)
- Answers depend on flux formulation

Surface Flux Experiments

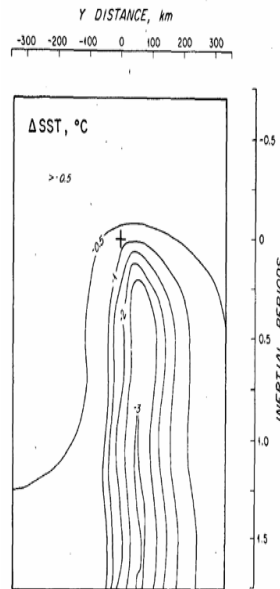
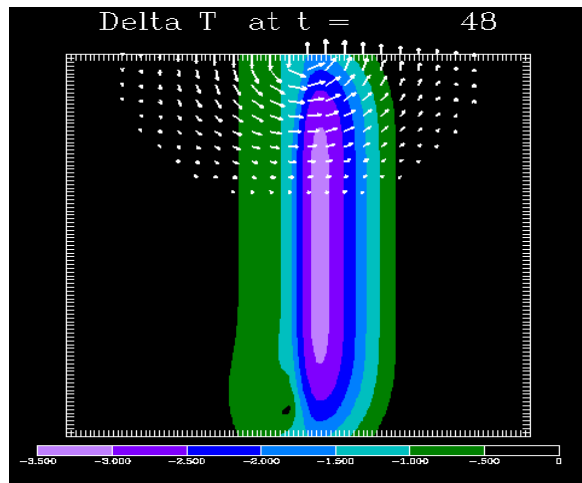


- D = Donelan Formulation
- V2.1.2 = Charnock
- D has less drag than V2.1.2
- Less drag means
 - Larger eye
 - Stronger winds (usually)
 - Higher central pressure

Ocean Mixing

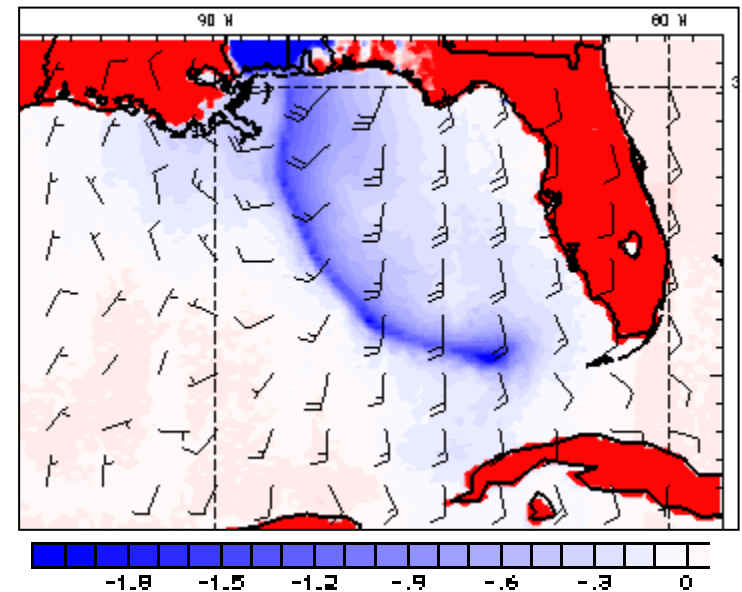
Comparison of OML and Full Ocean Models for Idealized Vortex

Mixed Layer Model



Full Ocean Model
Price (1981)

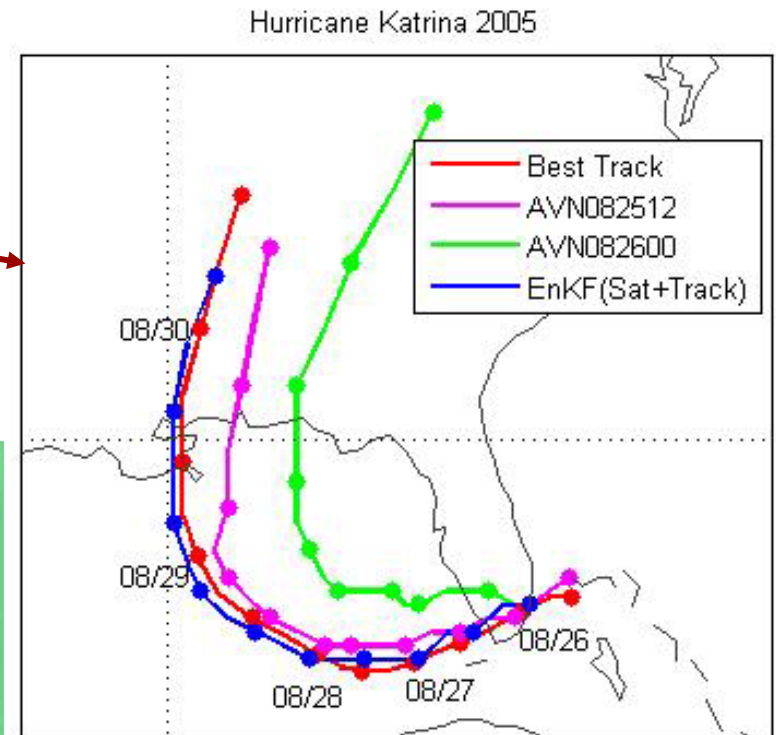
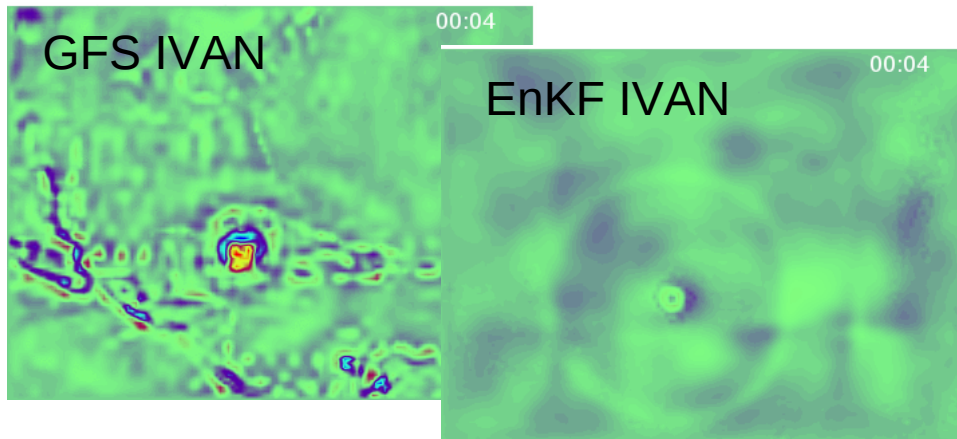
Katrina: 4-km grid



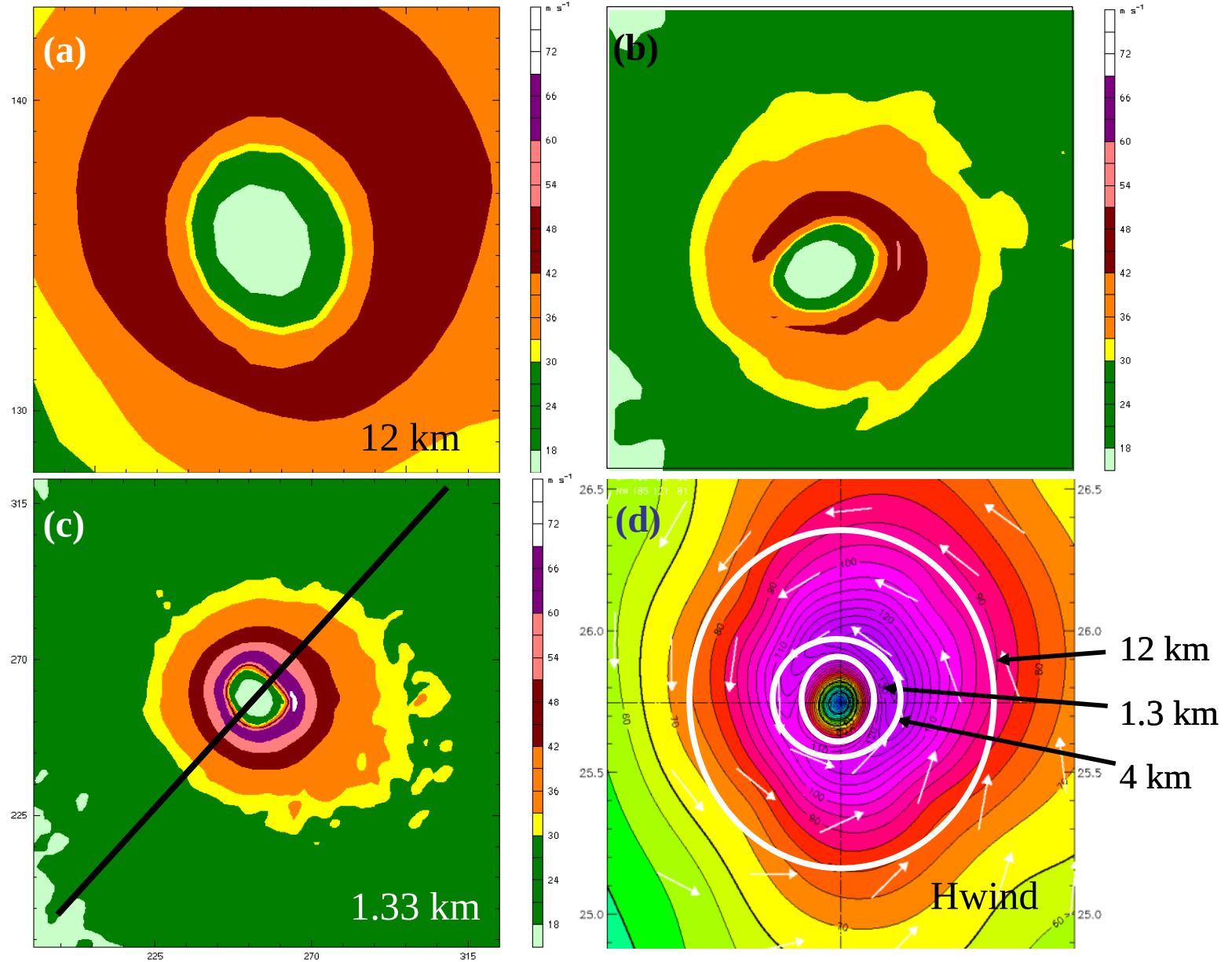
Maxima in both idealized calculations is 3.1 K

Initialization

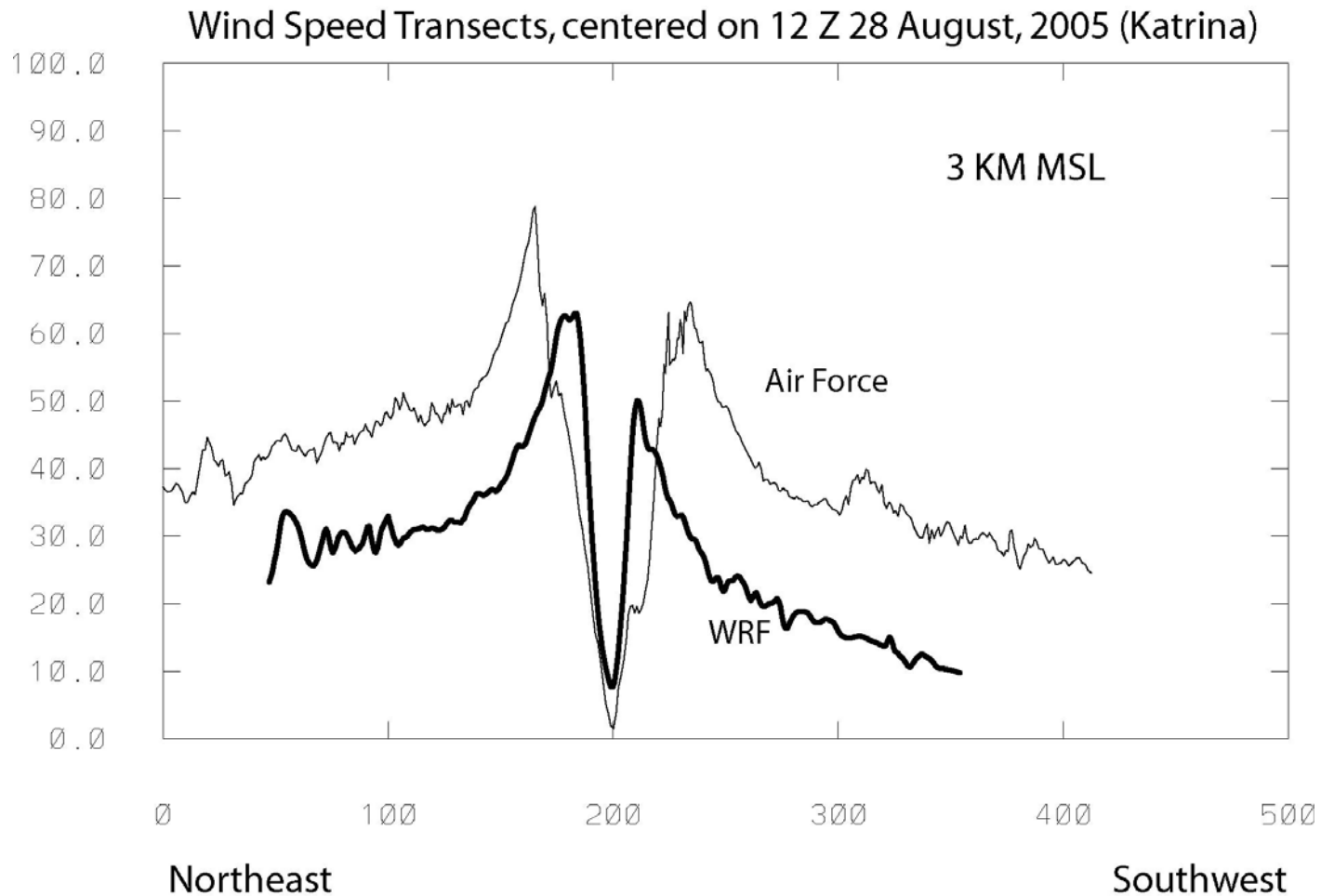
- Reduce model spinup (12 h)
- Improve intensity prediction < 2 days
- Methods
 - EnKF
 - 3DVAR
 - 4DVAR



10-m Wind Comparison

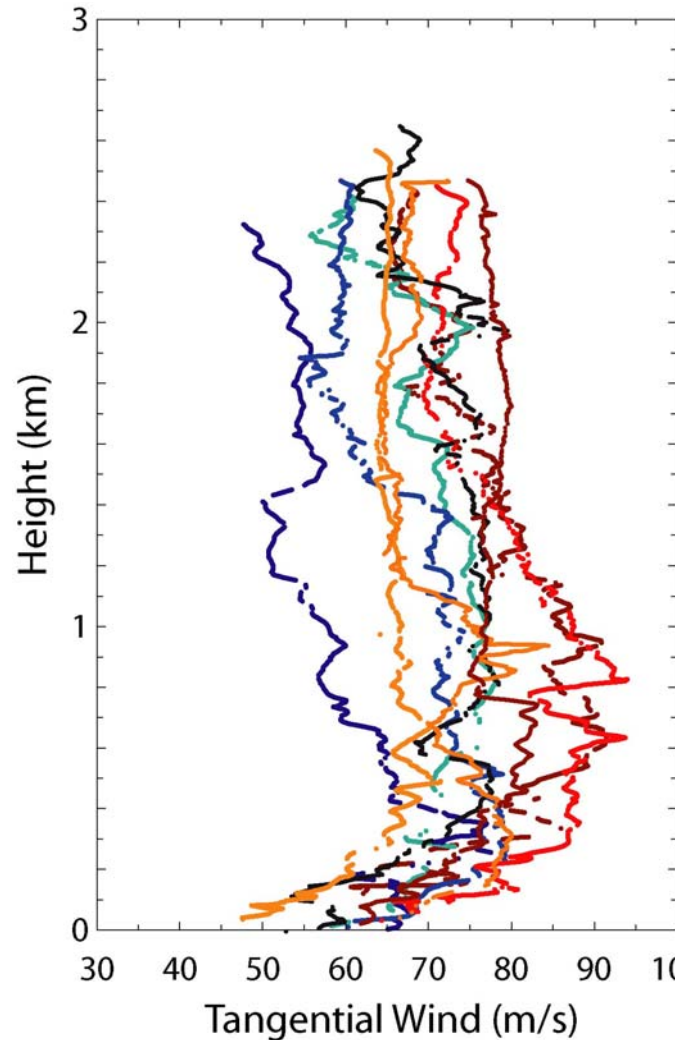


Radial Wind Profile: Katrina

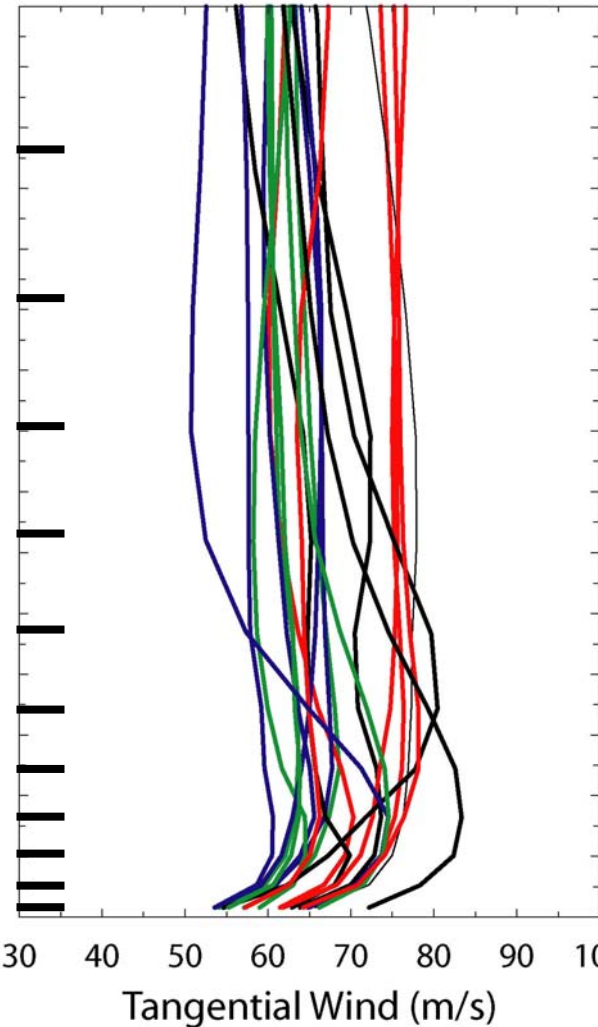


Wind Profiles: Katrina

NOAA P-3 17 UTC 28
– 00 UTC 29 August



AHW 19-23 UTC 28
August

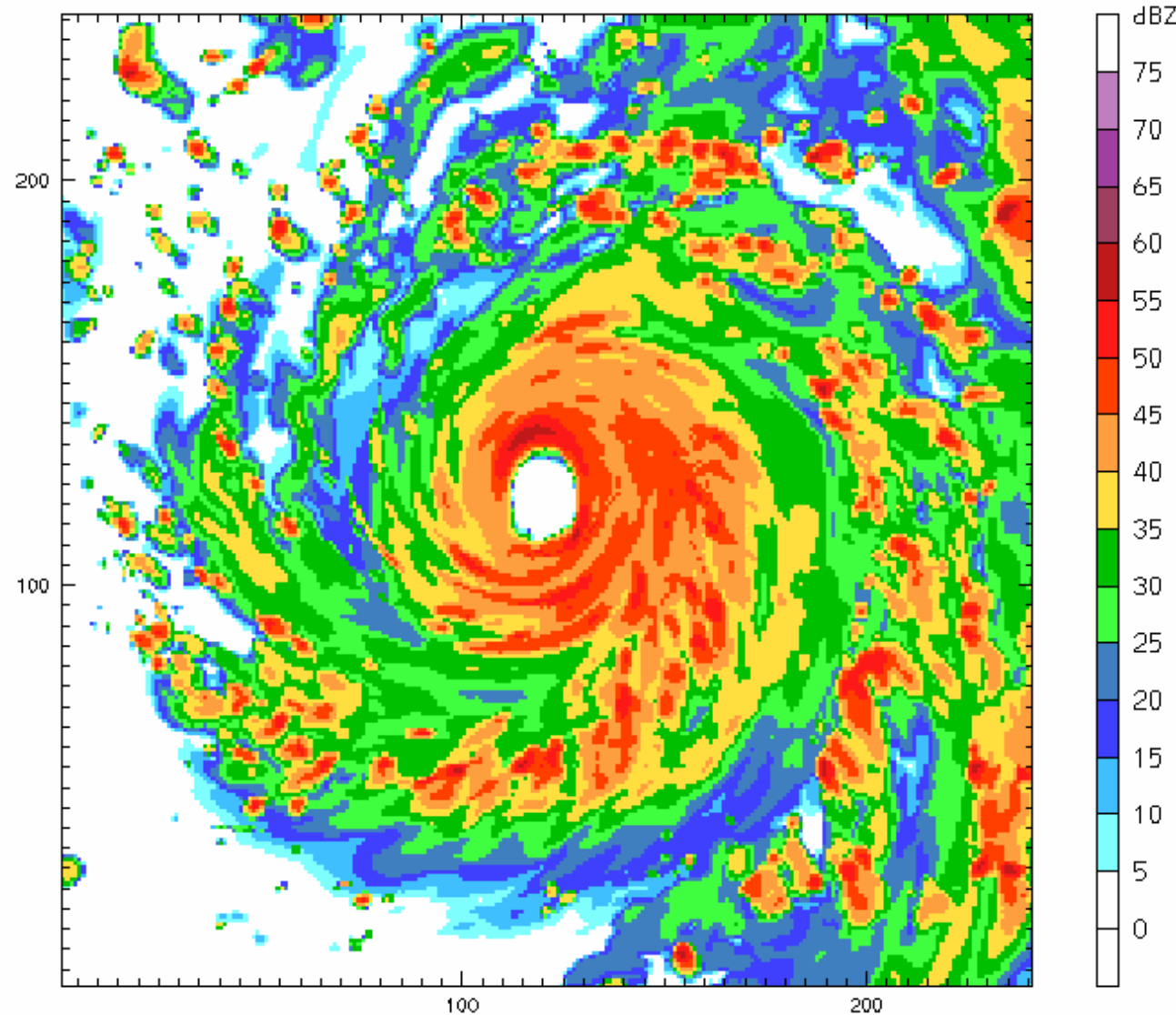


E
S
W
N

1 km EM-WRF -- NCAR/MMM Cd Test
Fcst: 30.00 h
Max Reflectivity

Init: 0000 UTC Sat 27 Aug 05
Valid: 0600 UTC Sun 28 Aug 05 (0200 EDT Sun 28 Aug 05)

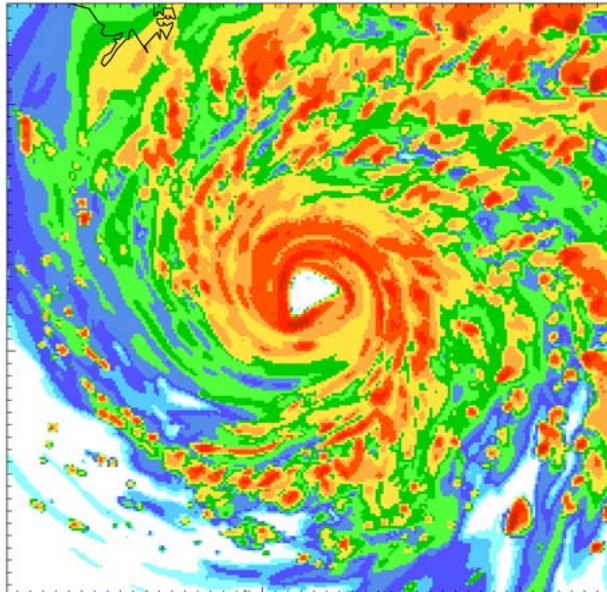
Reflectivity on 1.33- km Grid



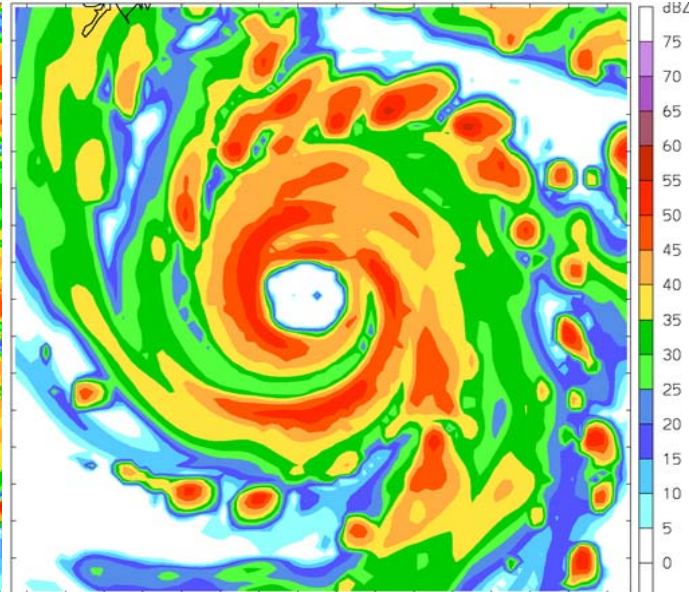
Model Info: V2.1.2 M No Cu YSU PBL WSM 3class Ther-Diff 1.3 km, 34 levels, 7 sec
LY: RRTM SW: Dudhia DIFF: simple KM: 2D Smagor

Rainbands: Katrina

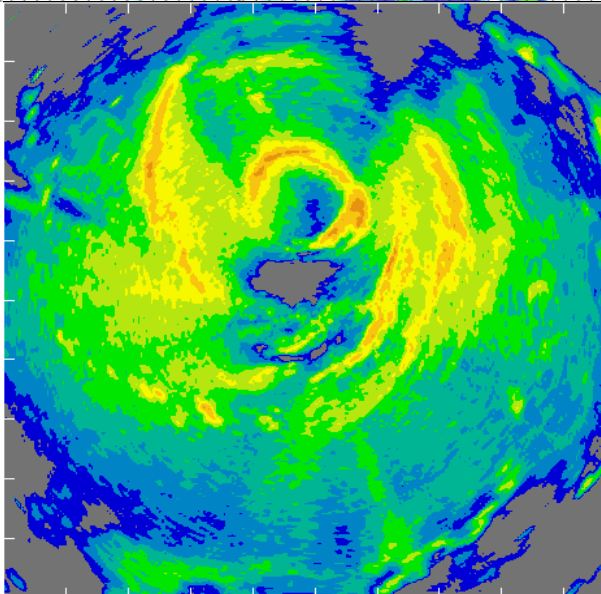
AHW
1.33 km
00 UTC
29 August



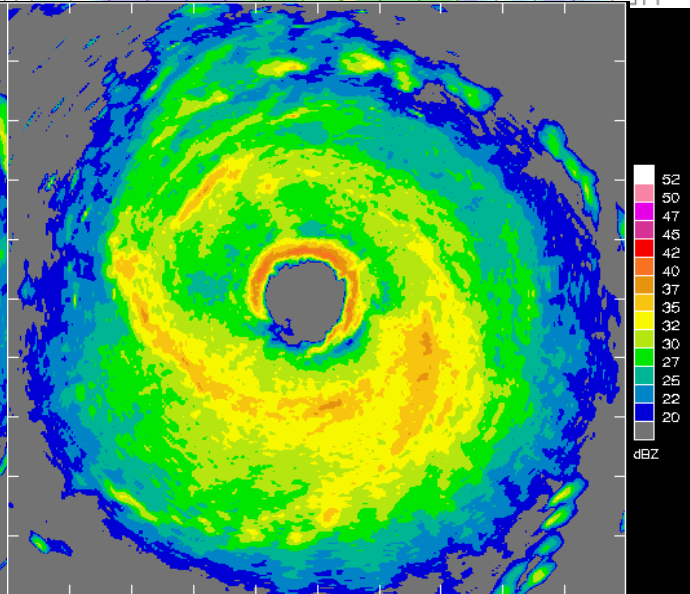
AHW
4 km
00 UTC
29 August



NOAA P-3
LF Radar
2317 UTC

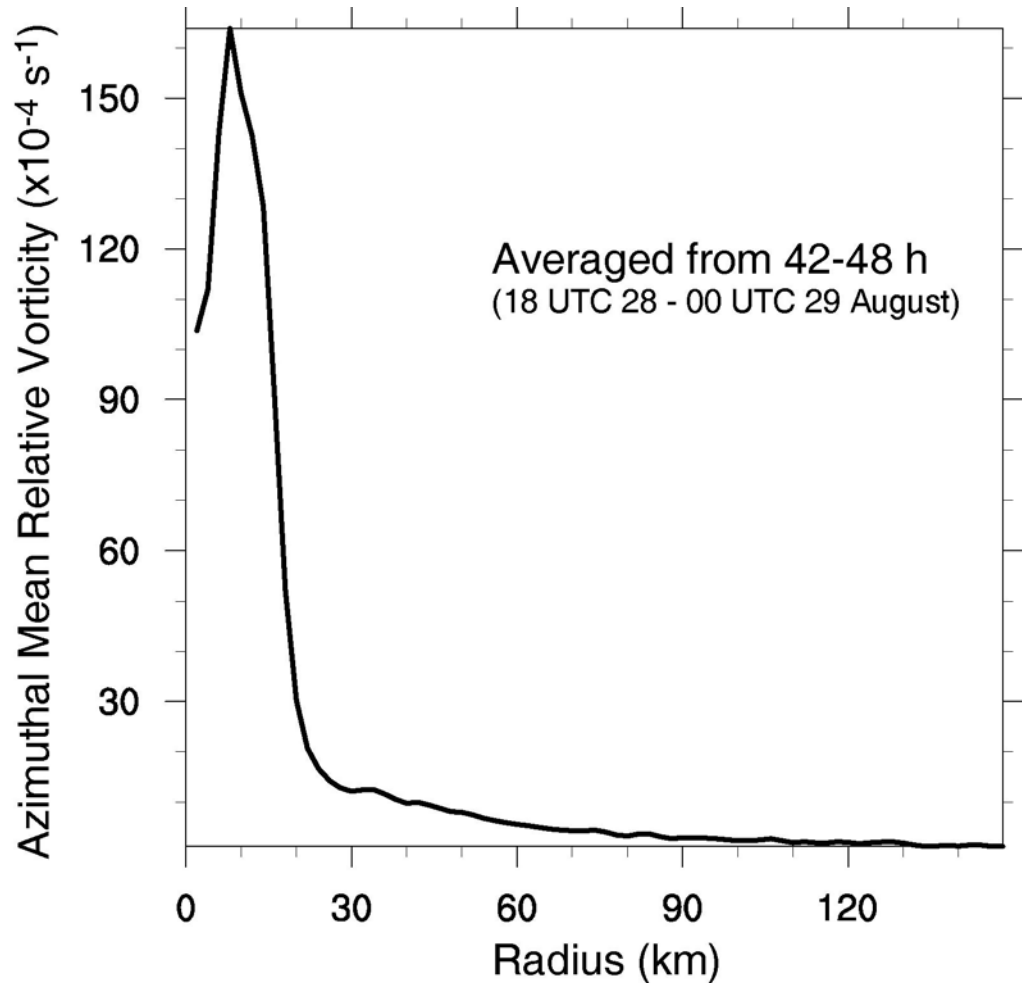


NOAA P-3
LF Radar
2347 UTC



Vorticity Profile: Katrina

$$C_{\lambda} = V_{\max} \left(1 - \frac{1}{n}\right)$$



Conclusions

- Flux Formulation
 - Apparently large sensitivity
 - Controls eye size, pressure-wind relationship
 - C_K perhaps greatest unknown (and important!!)
- Ocean Coupling
 - Columnar mixed-layer model capture most short-term effects of full ocean model
 - Need to incorporate altimetry data to initialize ML depth
- EnKF promising as initialization method
- Sub-2-km grid spacing necessary for inner core
 - Issue of spurious Rossby waves (Katrina and Rita)
 - Width of eye wall?
 - Rainbands show less cellular character
- 12-km AHW surprisingly good so far: Is 4-km still “no-man’s land”?
- Verification methods are obsolete

2006

http://www.wrf-model.org/plots/realtime_main.php

